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DIGITAL
MULTIMETER
4440



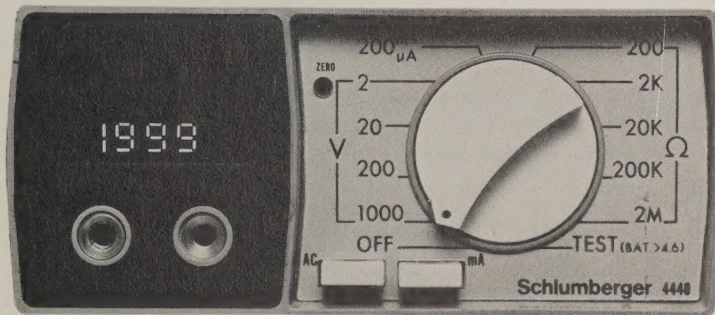
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DIGITAL MULTIMETER

MODEL 4440



SECTION 1 General

INTRODUCTION

This section presents the design and operating principles of the 4440 Digital Multimeter. Complete circuit diagrams and assembly drawings are included for reference in Section 2.

The 4440 incorporates all circuitry needed to make measurements of dc voltage and current, ac voltage and current, and resistance. The basic measuring circuit is a high impedance bipolar analogue to digital (A to D) converter operating on the dual-slope principle. All inputs other than dc volts are converted to dc volts for measurement by this circuit.

Resistance is measured by passing a scaled constant current through the unknown and measuring the dc voltage across it. Alternating voltages are converted to dc by a mean sensing, rms calibrated converter assembly, with a full scale output voltage of 200mV dc for all ranges. Current is measured by the voltage drop across a shunt. The full scale voltage across the shunt is 200mV.

The DC voltmeter and the several conversion circuits are interconnected by two push button switches and a rotary range switch which make possible decimal point switching, input ranging, gain changes in the A to D converter, and shared usage of the precision input attenuator.

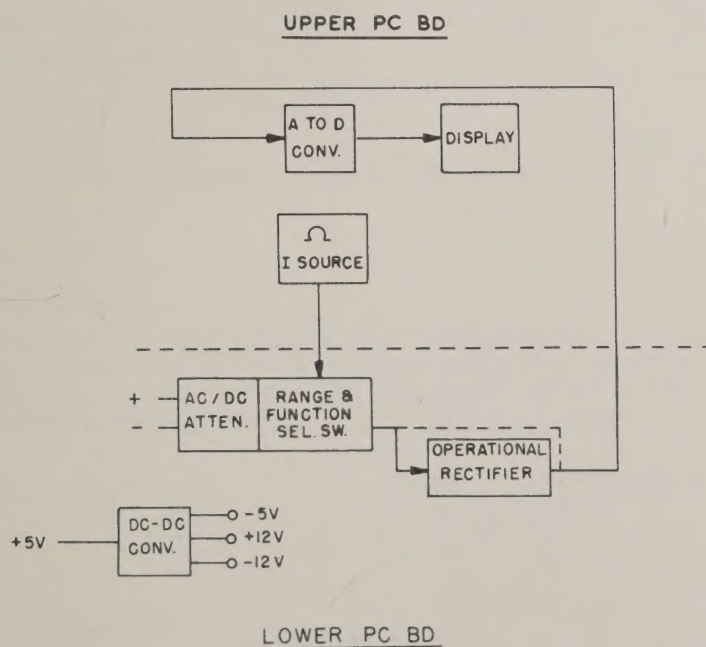


Fig. 1.1 Circuit Partitioning

DETAILED CIRCUIT DESCRIPTION

DC VOLTMETER CIRCUIT

The A to D converter is common to all measuring functions. The input voltage may be either 200mV dc or 2V dc depending on range setting. All the voltages are scaled to one of these ranges by suitable attenuators, shunts, or converters. The display has a maximum reading of 1999 accompanied by decimal points, polarity sign and an overrange indication.

The circuit operation will be explained with the aid of Waveforms Figure 1.2 and the Block Diagram Figure 1.3.

Dual Slope A to D Conversion

Dual slope conversion is an integrating method which has the following inherent advantages:

1. By proper choice of oscillator frequency, the effect of power frequency interference is reduced.
2. Internal clock frequency accuracy is unimportant since the input voltage is converted into a ratio of two time intervals.
3. Comparator threshold accuracy is unimportant.

The technique employed in the Model 4440 has the added advantage of not switching the input signal, eliminating a source of noise which can disturb the quantity being measured.

Figure 1.2 shows the waveforms associated with one conversion cycle. The equation relating E_{in} to a time ratio is as follows:

$$\frac{E_{in} T_1}{RC} = I_{REF} - \frac{E_{in}}{R} \frac{T_2}{C}$$

$$\text{since } T_1 + T_2 = T$$

$$T_2 = E_{in} \frac{T}{I_{REF} R}$$

$$E_{in} = \frac{T_2}{T_1 + T_2} I_{REF} R$$

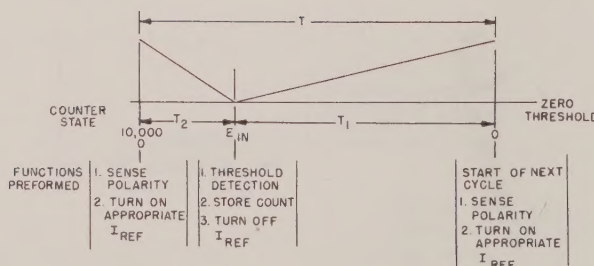


Fig. 1.2 Waveforms

Basic Logic

The A to D converter logic is incorporated on a MOS-LSI circuit. This includes the portion of the block diagram enclosed in dotted lines. The conversion period is fixed at 10 000 clock pulses. With a count advance from 9999 to 0000, the polarity of the integrator output is sensed and stored. Additionally, one of two current references is turned on based on the polarity data. When a comparator threshold is reached, the current reference is turned off, and prior to a new counter advance, the counter states are stored in a register. Meanwhile the counter continues counting.

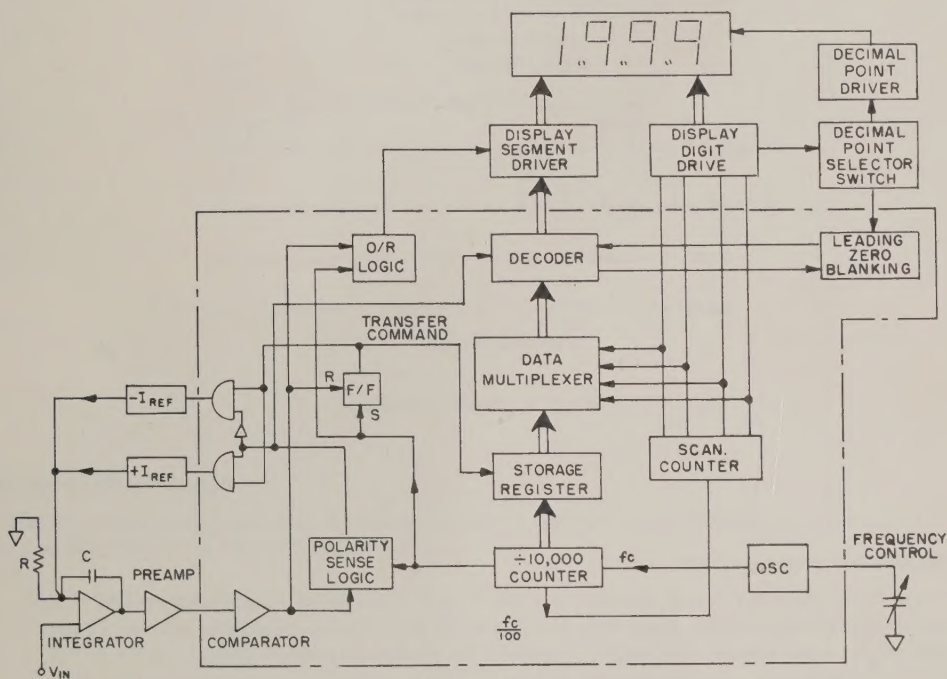


Fig. 1.3 A to D Converter Block Diagram

Strobed Display Operation

The display digits are sequentially energized with each digit updated approximately 100 times per second. The digit-select logic output and the seven segment logic outputs are synchronously supplied by the LSI circuit. (See Figure 1.4). Segments are energized on a 10% duty cycle basis to enhance the LED display efficiency.

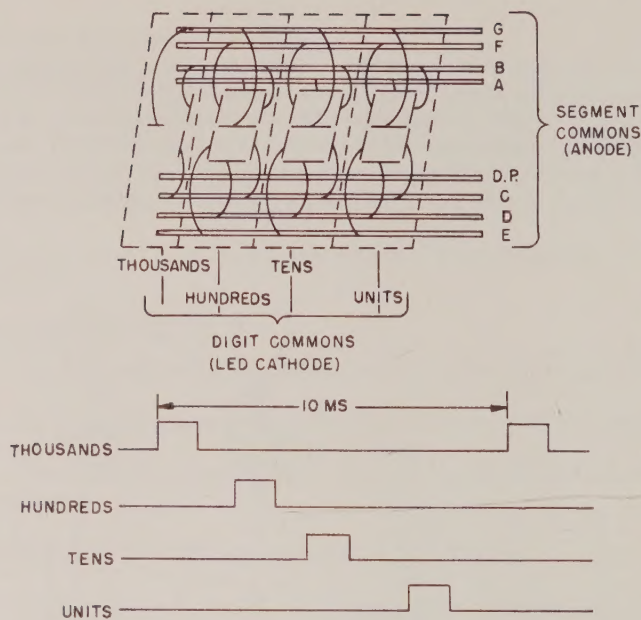


Fig. 1.4 Display Strobing

The Non-Inverting Integrator

The basic integrator circuit, Figure 1.5, consists of an operational amplifier connected in the non-inverting mode for high input impedance, and the logic-controlled current source. If, for example, an input voltage of +100mV is applied, the feedback amplifier causes point A to rise to 100mV producing a current through resistor R. In the absence of a reference current, this constant current charges capacitor C and point B will rise linearly to support this charge rate.

When, at the count of 10 000, a reference current is switched into point A, the reference source will supply the current through R and the remaining current will discharge capacitor C. Point B will then fall back towards zero taking 1000 clock bits to do this, giving a display of 100.0. Since one complete period is 10 000 counts, the rise will take 9000 clock bits and the fall will take 1000 clock bits. Other input voltages will give rise to corresponding fall times and displays.

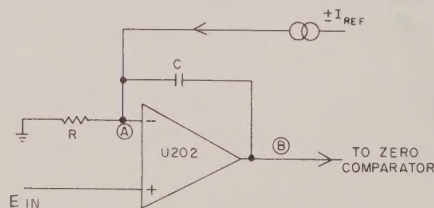


Fig. 1.5 Integrator Circuit

Offset Adjustment

To compensate for offset voltages in U202, which would produce a continuous ramp at B with zero input, the ground of the integrating resistor R is returned to an adjustable voltage, low impedance source as shown in Figure 1.6.

Resistor R231 and its associated resistors provide a 50Ω source, adjustable to $\pm 8\text{mV}$ to accommodate an 8mV possible offset voltage in the amplifier. The offset adjustment need not be changed when changing ranges.

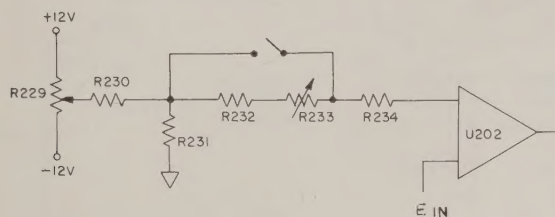


Fig. 1.6 Offset Adjustment

Reference Current Circuits

The reference current generators consist of a common-base transistor constant current source. The positive reference is shown in Figure 1.7.

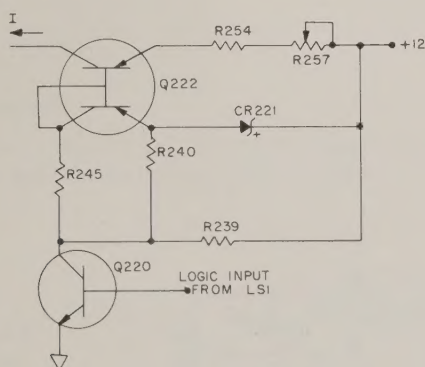


Fig. 1.7 Reference Current Circuit

INPUT ATTENUATION

On the 200mV, 2V and 200 μ A ranges, E_{in} is applied without attenuation as shown in Figure 1.8. A common attenuator is used for both ac and dc measurements on the other voltage ranges as shown in Figure 1.9.

A 2 pole RC network gives rejection of series mode interference.

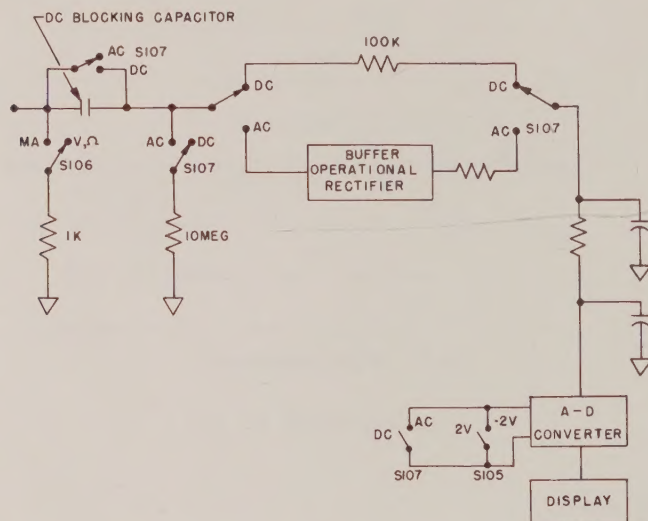


Fig. 1.8 200mV, 2V and Current Ranges

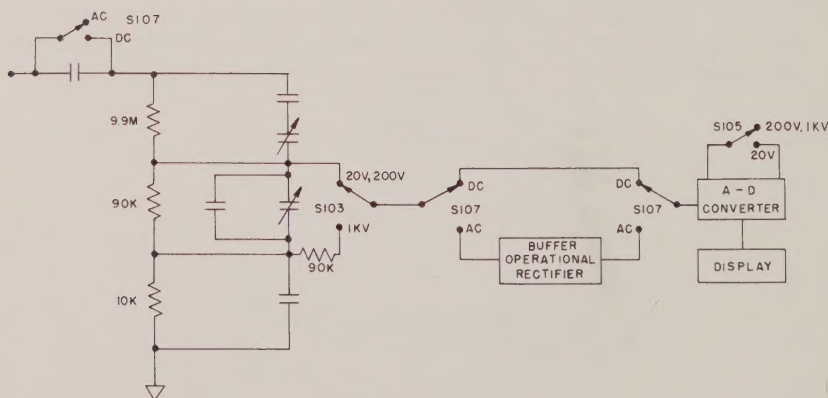


Fig. 1.9 20V, 200V and 1kV Ranges

AC BUFFER AND OPERATIONAL RECTIFIER (AC CONVERTER)

The measurement of alternating voltages is accomplished by a mean sensing, rms calibrated, operational rectifier shown in a simplified form in Figure 1.10.

The diodes at the input protect the high input impedance FET buffer stage during overload. Following the buffer circuit is the input network of the operational rectifier which sets the gain for the 200mV and 2V basic ranges.

The half wave rectified signal at point A is filtered by a three pole low pass filter and is scaled by the feedback components so that the DMM displays the rms reading, assuming a sine-wave input.

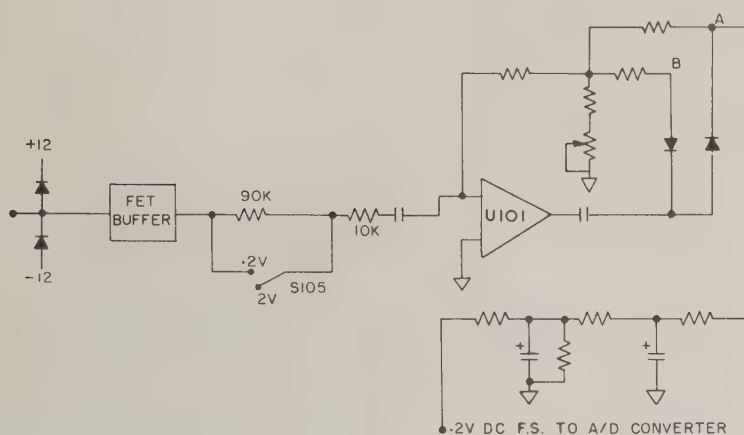


Fig. 1.10 AC Converter Circuit

RESISTANCE MEASUREMENT

The ohms circuit is shown in Figure 1.11. Fuse F102, diodes CR116 and CR115, and resistor R120 form a protection network for the current reference source.

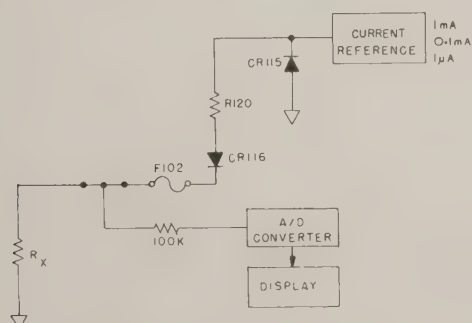


Fig. 1.11 Ohms Measurement Circuit

POWER SUPPLY

The battery charger and battery supply are shown in Figure 1.12. The fuse provides a current limiting resistance.

A dc-dc converter is used to generate the -5V, +12V and -12V power rails.

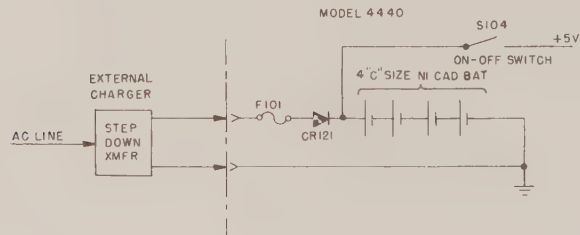


Fig. 1.12 AC Line/Battery Operation

CALIBRATION

All calibration adjustments can be performed without uncasing the instrument.

The A.C. gain potentiometer (R146) is located in the rear L.H. corner of the DMM, adjustment being possible with a narrow bladed insulated screwdriver or trimming tool. All other adjustments are accessible when the front dial plate is removed. This may be effected by inserting a blunt pointed implement into the zero set control access hole and carefully prying up the plastic front plate which will snap out.

The following calibration checks should be carried out after any repairs or whenever the instrument appears to be operating incorrectly.

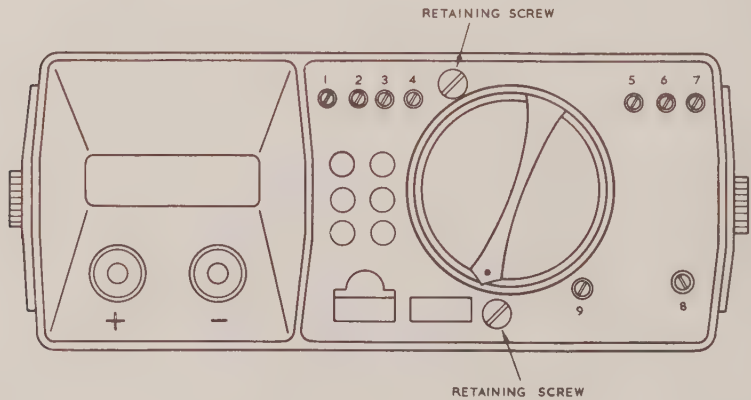


Fig. 1.13 Calibration Adjustments

- (a) Select Battery TEST position on mode selection switch, reading should be at least 4.6V. If low or blank, recharge the batteries before proceeding with the following procedure.
- (b) Select the 200mV DC range. Short together the input leads. Reading should be zero. If incorrect, correct by adjustment of R229 (adjustment No. 1 on front panel).
- (c) Apply +190.0mV DC, adjust R257 (adjustment No. 2 on front panel) for correct display.
- (d) Reverse input leads, polarity should appear -ve. If necessary, correct display by adjustment of R247 (adjustment No. 3 on front panel).
- (e) Replace input leads into correct sockets, select 2V DC range on mode switch. Apply 1.900V to input. If necessary, correct display by adjustment of R233 (adjustment No. 7 on front panel).
- (f) The following procedure requires the use of known value resistances preferably sub-standard quality.
- (g) Select the 2M resistance range, apply a 1.900M or similar valued resistance and correct reading by adjustment of R241 (adjustment No. 4 on front panel) if necessary.

Now select the 200K range and change the resistance to 190.0K or similar, if necessary readjust R241. Now change range back to 2M range using the same resistance. Split any deviation between ranges by adjustment of R241.

- (h) Select the 20K range, apply a standard resistor of 19.00K or similar. If necessary, correct the display by adjustment of R259 (adjustment No. 5 on front panel).
- (j) Select the 2K range, apply a standard resistor of 1.900K or similar. If necessary, correct the display by adjustment of R258 (adjustment No. 6 on front panel).
- (k) Select 200mV AC on the mode selection switch, depress the AC push button. Apply 190.0mV (50Hz - 1kHz sine-wave). If necessary, correct reading by adjustment of R146 (adjustment on rear of case).
- (l) Select 1000V AC. Apply 1000V AC at 2kHz. If necessary, correct reading by adjustment of C103 (adjustment No. 9 on front panel) to 1000 ± 2 digits.
- (m) Select 200V AC. Apply 190.0V AC @ 8kHz. If necessary, correct reading by adjustment of C106 (adjustment No. 8 on front panel) to $190.0V \pm 2$ digits.
- (n) Repeat steps (l) and (m) as necessary.

SECTION 2

Servicing

COMPONENT PARTS LIST			
ABBREVIATIONS			
Circuit References		Component Composition (Cont'd)	
B	Battery	VARIABLE RESISTORS	
C	Capacitor (μF)	Wirewound Preset Single Turn	WWPS
CSR	Thyristor	Wirewound Preset Multiturn	WWPM
CR	Diode	Wirewound Front Panel Single Turn	WWFS
F	Fuse	Wirewound Front Panel Multiturn	WWFM
U	Integrated Circuit	Carbon Preset Single Turn	CAPS
L	Inductor	Carbon Preset Multiturn	CAPM
LP	Lamp (including Neon)	Carbon Front Panel Single Turn	CAFS
LK	Link	Carbon Front Panel Multiturn	CAFM
M	Meter	Cermet Preset Single Turn	CMPS
MSP	Mains Selector Panel	Cermet Preset Multiturn	CMPM
PL	Plug	Cermet Front Panel Single Turn	CMFS
R	Resistor (Ω)	Cermet Front Panel Multiturn	CMFM
RL	Relay		
S	Switch		
SK	Socket		
T	Transformer		
TP	Terminal Post (or Test Point)		
Q	Transistor		
V	Valve		
A	Other Components		
Also Used:-		CAPACITORS	
Z	Resistor Module	Air	AIR
Component Composition		Aluminium Electrolytic	ALME
FIXED RESISTORS		Aluminium Solid	ALMS
Carbon Composition	CACP	Polycarbonate	CARB
Carbon Film	CAFM	Ceramic	CERM
Cracked Carbon	CKCA	Polyester Foil	ESTF
Metal Film	MEFM	Polyester Metallised	ESTM
Metal Oxide	MEOX	Glass	GLAS
Power Wirewound	PQWW	Mica	MICA
Precision Wirewound	PRWW	Metallised Lacquer	MLAC
Temperature Sensitive	TEMP	Paper Foil	PAPF
Thick Film	TKFM	Paper Metallised	PAPM
Thin Film	TNFM	PTFE	PTFE
Voltage Sensitive	VOLT	Polystyrene	STYR
		Tantalum Dry	TAND
		Tantalum Foil	TANF
		Tantalum Wet	TANW

DISMANTLING PROCEDURE

Fuse access only

- (1) Remove the two thumb screws (item 3).
- (2) Screw one of the thumb screws into the tapped recessed stud and then grasping the DMM in one hand, gently ease out the battery pack (item 5) using the inserted thumb screw as a grip.

Battery and spare fuse access

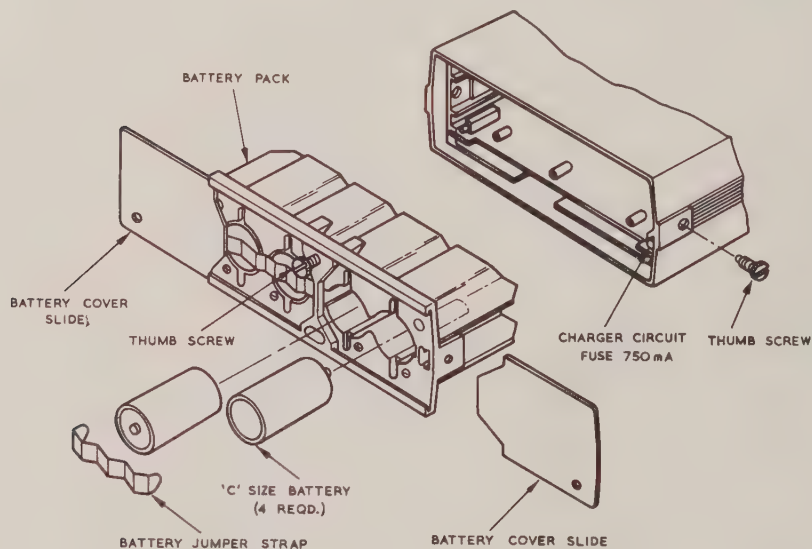
- (3) Slide out the battery covers (items 6 and 7).
- (4) Spring out the battery shorting strips (item 9).
- (5) Slide out the battery cells.

Reverse the above sequence for reassembly.

P.C.B. removal

- (1) Remove the battery pack as detailed above.
- (2) Gently snap out the front dial plate (item 2) by inserting a blunt pointed implement into the zero set control hole (refer to insert) and gently plying up until the plate snaps out.
- (3) Note the position of the range selection knob (item 22) index mark.
- (4) Remove screws (item 13) and gently pull out the P.C.B. package from the DMM case.

Reverse the above sequence for reassembly taking care to reposition knob (item 22) as noted above and ensuring that the whole assembly is not pushed forward allowing the detent springs and rollers (items 23 and 24) to spring out of position.



COMPONENT PARTS LIST

For
MODEL 4440 MULTIMETER
(General Assembly)

Item No.	General Description
2	Dial, Printed
3	Screw, Thumb
4	Handle
5	Case Assy, Battery
6	Cover, Battery
7	Cover, Battery
9	Contact, Battery Shorting
10	Battery, C size, 2 AH
11	Fuse, 0.031A, 8AG
12	Fuse, 0.750A, 8AG
17	Shaft, Range Switch
18	Shield, Cover
19	Shield, AC Cover, Outside
20	Socket, Fuse
21	Spring
22	Knob
23	Spring, Detent
24	Roller, Detent
25	Case, Painted
Lead Assy. Battery Charger, 210-260V 50-400Hz	

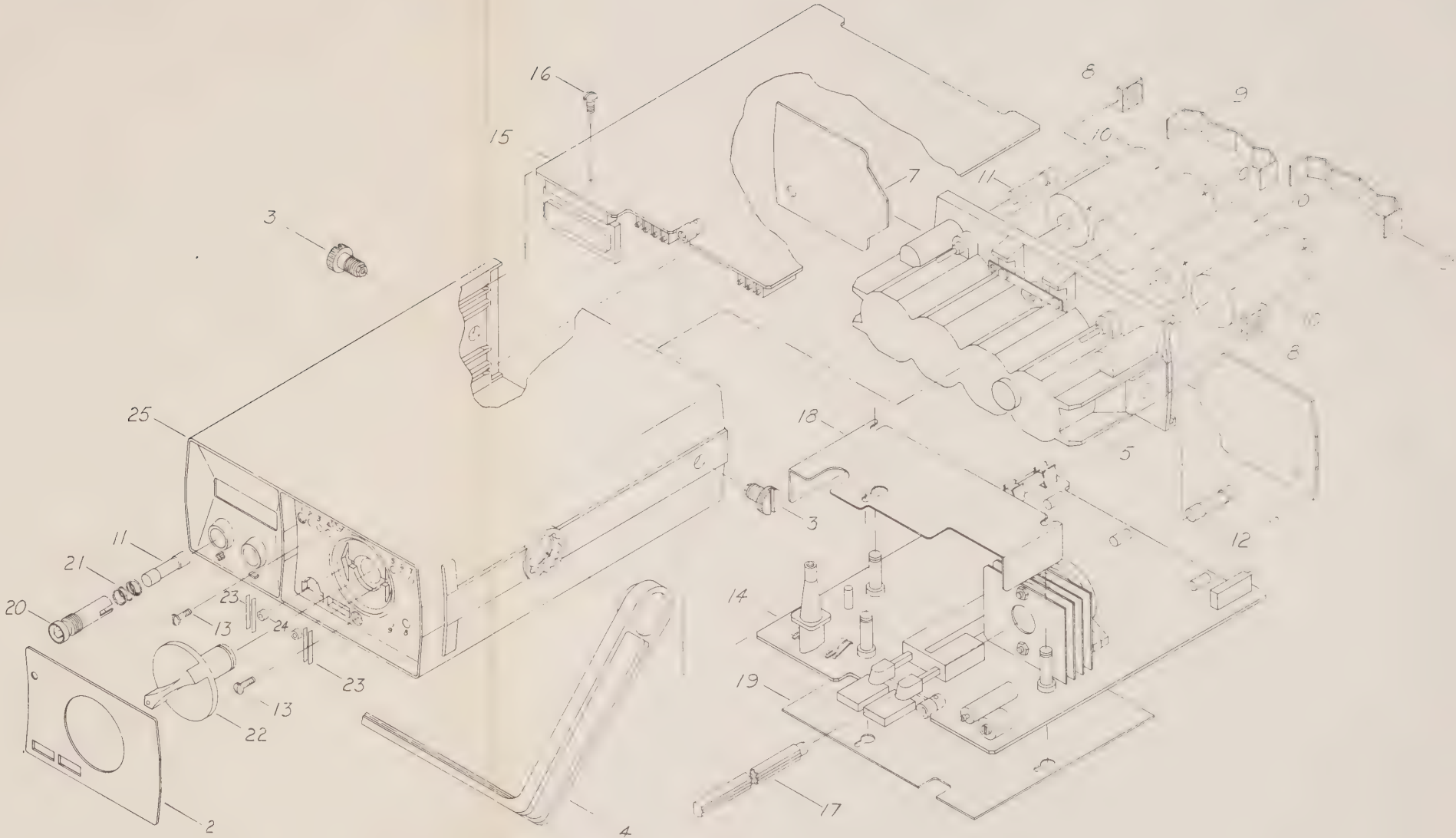
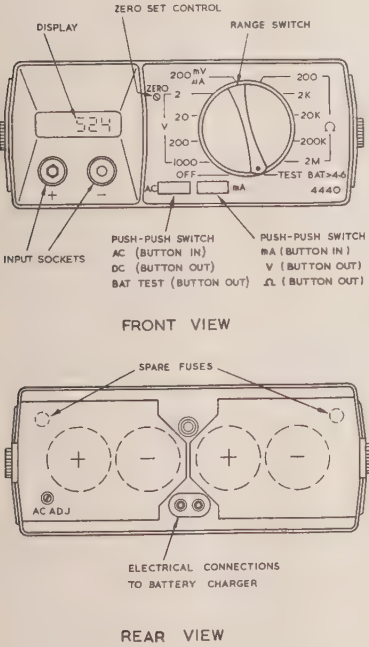


Fig. 2.1 Assembly

COMPONENT PARTS LIST

For
PCB AD 10669002

(Fig. 2.2)

Cct Ref.	General Description			
C101	CERM	.02	1kV	20%
C102	MICA	20p	500V	5%
C103	CERM	.8-26p	750V	
C104	MICA	500p	500V	2%
C105	ESTM	.22	250V	20%
C106	CERM	10-60p	250V	
C107	ESTM	5000p	100V	2%
C109	CERM	.01	100V	20%
C110	CERM	.01	100V	20%
C111	MICA	20p	500V	5%
C112	TAND	15	10V	20%
C113	TAND	1.0	50V	20%
C114	CERM	.0047	125V	-10% +50%
C118	TAND	15	10V	20%
C119	MICA	3p	300V	±1%
C120	MICA	3p	300V	±1%
C121	CERM	.01	100V	20%
C123	TAND	15	10V	20%
C124	TAND	2.2	15V	20%
C125	TAND	2.2	15V	20%
C126	CERM	750p	1kV	10%
C127	CERM	150p	1kV	10%
C128	TAND	15	10V	20%
C130	ALME	1600	10V	+50% -10%
C131	CERM	.01	100V	20%
C132	TAND	15	10V	20%
C133	CERM	.01	100V	20%
C134	CERM	330p	1kV	10%
L101	Choke	22μH		10%
F101	Fuse	0.75A 8AG		
	Button, push			
S106	Switch, Push Button			
S107	Switch, Push Button			
	Switch Assy, Range			
T101	Transformer			
J101	Connector Molex			
	Support, L.E.D. Display			

Cct Ref.	General Description			
R103	MEFM	1k	1/4	0.1%
R105	Matched Set			
R106				
R111				
R112				
R107	CACP	1.5k	1/4	10%
R108	CACP	18	1/4	10%
R109	CACP	47	1/4	10%
R113	MEFM	90.9k	1/10	1%
R114	MEFM	100k	1/4	1%
R115	CACP	10M	1/4	5%
R116	CACP	1.5k	1/4	10%
R117	CACP	1.5k	1/4	10%
R118	CACP	22k	1/4	10%
R119	CACP	62	1/4	10%
R120	CACP	390	1/4	10%
R122	MEFM	100k	1/2	1%
R124	CACP	47k	1/4	10%
R125	CACP	22k	1/4	10%
R126	CACP	33k	1/4	10%
R127	Matched Set			
R128				
R129				
R130				
R131	MEFM	10k	1/10	1%
R132	MEFM	3.01k	1/10	1%
R133	MEFM	3.01k	1/10	1%
R134	MEFM	30.1k	1/10	1%
R135	MEFM	30.1k	1/10	1%
R136	MEFM	75k	1/10	1%
R137	MEFM	30.1k	1/10	1%
R138	CACP	100k	1/4	10%
R139	CACP	100k	1/4	10%
R140	CACP	15M	1/4	5%
R141	CACP	15M	1/4	5%
R142	CACP	18	1/4	10%
R145	MEFM	464	1/10	1%
R147	CACP	5.6k	1/4	5%
R146	WWPM	50		10%
Q101	Transistor 2N5354			
Q102	Transistor 2N5354			
Q103	Transistor 2N2712			
Q104	Transistor 2N2712			
Q105	Transistor E102			
Q106	Transistor 2N4126			
Q107	Transistor 2N5354			
U101	I.C. LM301A			
CR105 to CR108	Diode SD3			
CR111	Diode SD3			
CR113	Zener ZY12			
CR114	Zener ZY12			
CR115	Diode FD333			
CR116	Diode 1N4004			
CR121	Diode 1N4004			
CR122	Diode FD333			
CR123	Diode FD333			
CR124	Diode SD3			
CR125	Diode SD3			

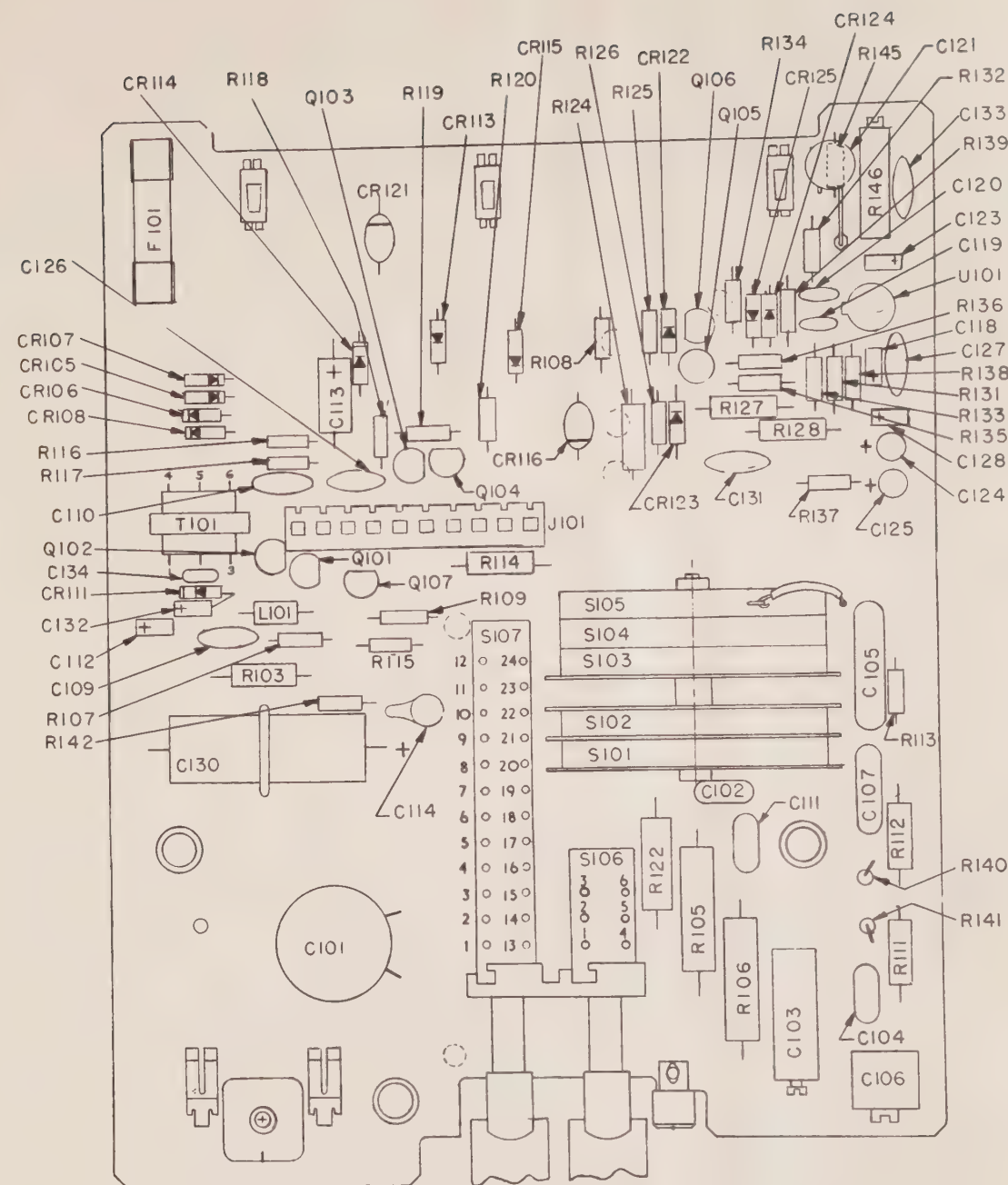
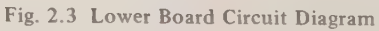


Fig. 2.2 Lower Board Assembly



For
PCB AD10669001

Cct Ref.	General Description			
C202	CERM	220p	1kV	10%
C203	CERM	330p	1kV	10%
C204	CERM	600p	500V	10%
C205	CERM	1200p	500V	10%
C206	ESTM	2.2	250V	10%
C207	CERM	68p	1kV	10%
C208	ESTM	.22	250V	20%
C209	ESTM	.68	250V	10%
C212 to C214	TAND	8.2	15V	20%
C215	CERM	.01	100V	10%
C216	CERM	2400p	500V	10%
C217	CERM	0.1	10V	+80% -20%
Z201	Res. Module			
Z202	Res. Module			
Z203	Res. Module			
Z204	Res. Module - REF			
Z206	Res. Module + REF, Ω			
SK201	SKT Receptacle L.S.1.			
L201	Choke	22 μ H		10%
A201	Display L.E.D. 3 1/2			
	Switch Assy, Range			
R201	CACP	390	1/4	10%
R209	CACP	22k	1/4	10%
R210	CACP	6.8k	1/4	10%
R211	CACP	22k	1/4	10%
R213	CACP	18	1/4	10%
R222	CACP	6.8k	1/4	10%
R223	CACP	6.8k	1/4	10%
R224	CACP	51k	1/4	10%

R225	CACP	6.8k	1/4	10%
R230	MEFM	49.9k	1/10	1%
R231	MEFM	49.9	1/4	5%
R232	MEFM	20.5k	1/4	1%
R234	MEFM	2.37k	1/4	1%
R236	MEFM	24.9k	1/4	1%
R238	MEFM	2.74k	1/4	1%
R240	MEFM	2.37k	1/4	1%
R242	MEFM	35.7k	1/4	1%
R243	MEFM	5.76M	1/4	1%
R246	MEFM	2.37k	1/4	1%
R248	MEFM	14k	1/4	1%
R254	MEFM	14k	1/4	1%
R255	MEFM	5.62k	1/4	1%
R256	MEFM	56.2k	1/4	1%
R261	MEFM	110k	1/4	1%
R229	WWPM	50k		10%
R233	WWPM	2k		10%
R241	WWPM	5k		10%
R247	WWPM	2k		10%
R257	WWPM	2k		10%
R258	WWPM	1k		10%
R259	WWPM	10k		10%
CR201	Diode SD3			
CR221	Zener IN821			
CR223	Zener IN821			
CR228	Zener IN821			
Q201 to Q204	Transistor 2N3605			
Q205 to Q208	Transistor NN7000			
Q209 Q210 to Q217	Transistor 2N3605 Transistor 2N5355			
Q220	Transistor 2N3605			
Q222	Transistor TD401A			
Q224	Transistor TD101A			
Q225	Transistor 2N5354			
Q226	Transistor 2N3605			
Q227	Transistor TD401A			
Q229	Transistor 2N2712			
Q230	Transistor 2N2712			
U202	I.C. LM308			
U203	I.C. M.O.S. L.S.I.			

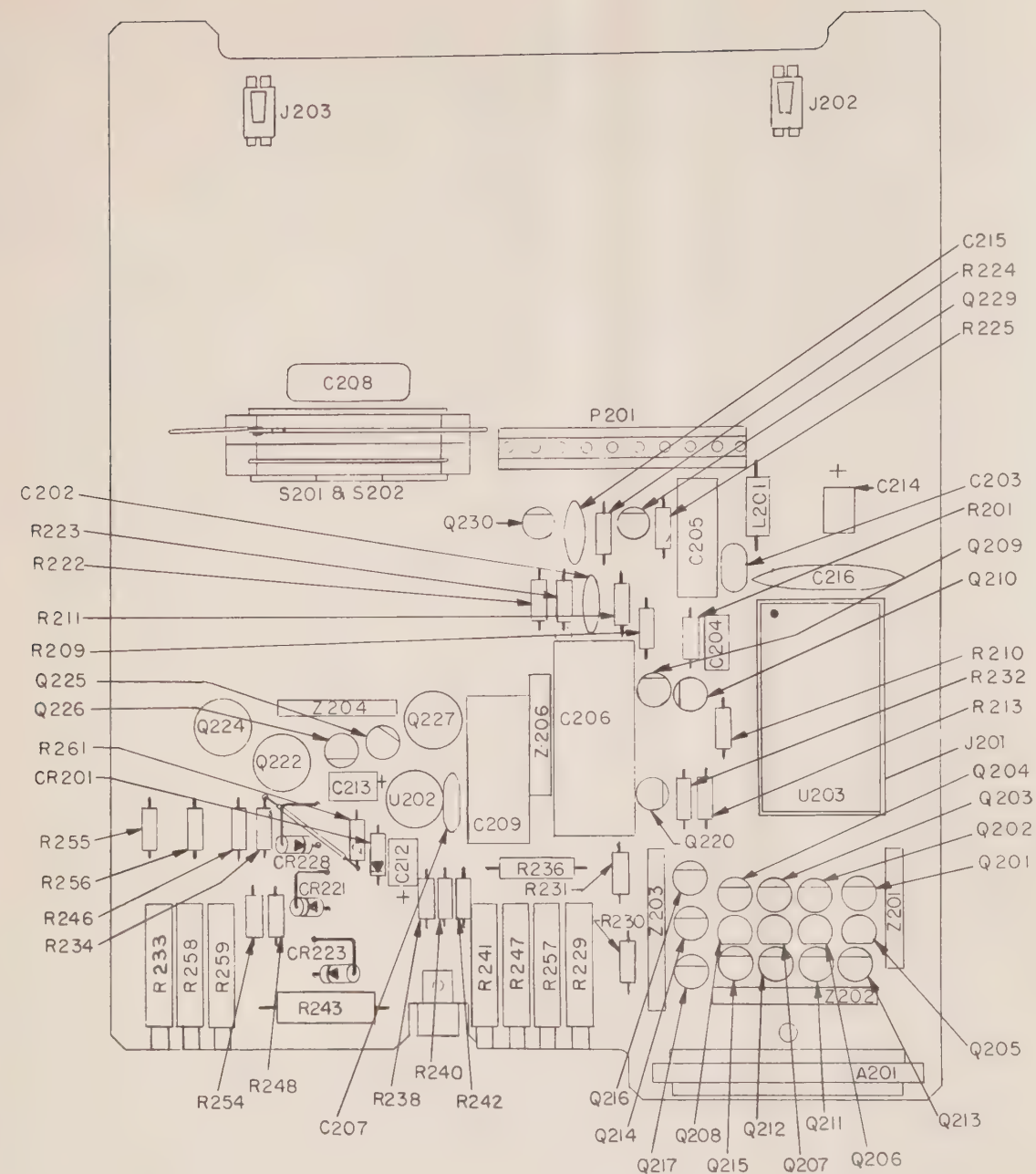


Fig. 2.4 Upper Board Assembly

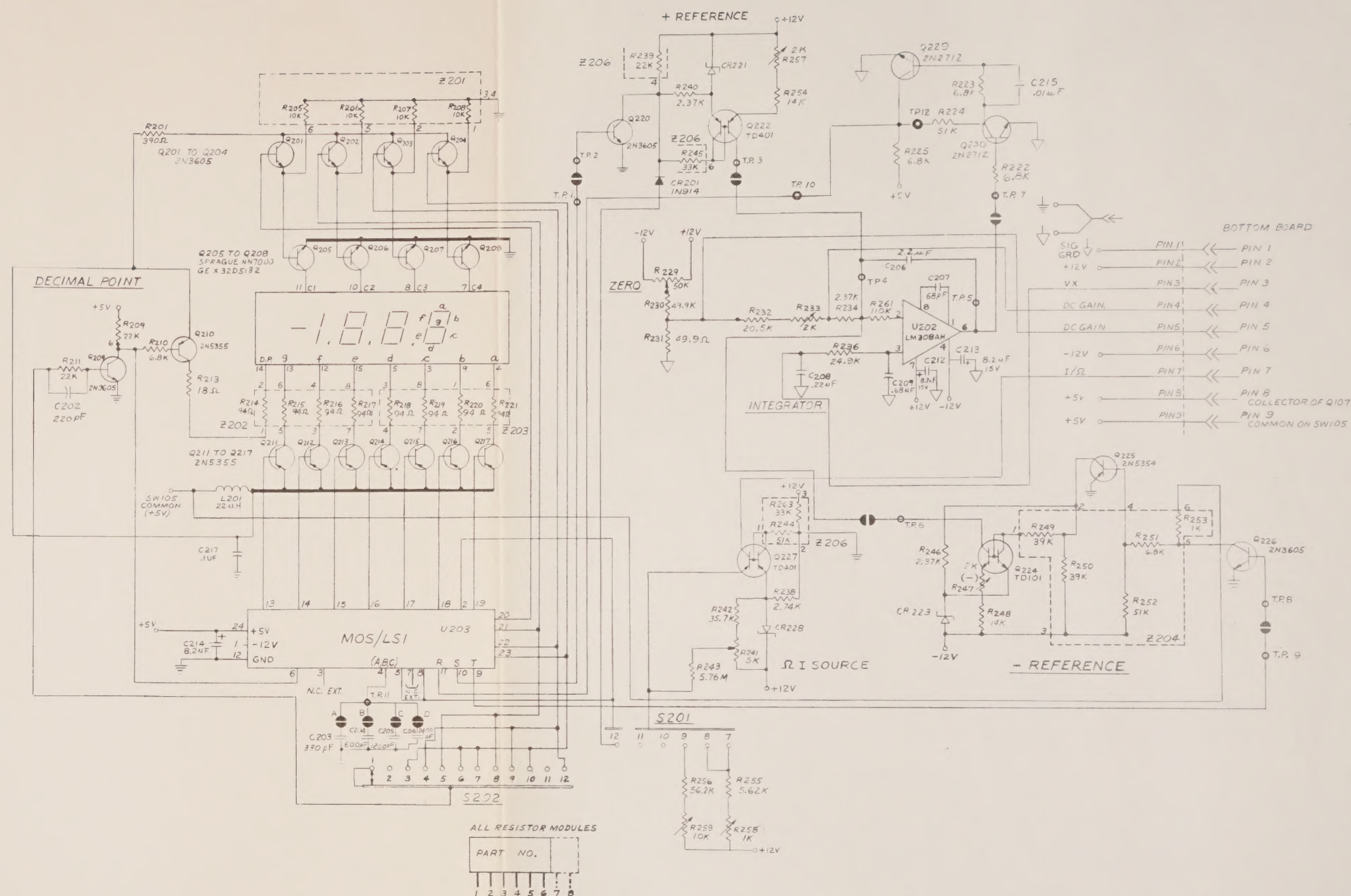


Fig. 2.5 Upper Board Circuit Diagram

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